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(54) METHOD OF PRODUCING CHAMOTTE-BASED MOULDING SANDS FOR FOUNDRY PURPOSES

(71) We, CHAMOTTE- UND TONWERK KURT HAGENBURGER, a German Company of 6719 Hettenleidelheim, Hauptstr. 82, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a new moulding material for foundries for the casting of steel, iron and non-ferrous metals. The conventional moulding materials used heretofore in foundries are natural sands, synthetic, i.e. washed, dried and accurately graded quartz sand, crushed and graded chamotte sand, chromium ore sand and zirconium sands.

Natural sands and synthetic quartz sands are the moulding materials most frequently used in foundries, since they are available cheaply in large quantities. Apart from this factor, the synthetic quartz sands are distinguished particularly in that they can be bound with all the binders known for foundry purposes, such as bentonite, starch, water glass, natural and synthetic linseed oils, synthetic resins, such as phenolic resins and furan resins, etc.

Continual improvements in quality of both sands and binders have enabled quartz sands to be used for small, medium-sized and in some cases large castings of weights of up to 30 metric tons each. The disadvantages of quartz sand are that the quartz grain undergoes the known quartz-tridymite-cristobalite phase changes when subjected to thermal stress, i.e. on heating. These changes of phase are accompanied by abrupt volume variations and expansion effects. Under thermal stress, these effects due to the mineralogical structure, result in cracking of the moulds made in quartz sand and are therefore the cause of undesirable sand expansion faults. The faster a mould can be filled with molten steel, the less chance there is for such sand expansion faults to become noticeable. The longer it takes to fill a mould with molten steel or iron, as is the case, for example, with large castings weighing over 30 metric tons, the greater the chance for quartz sand expansion to occur in the parts of the mould which are subjected to relatively long periods of thermal stress due to thermal conduction or radiation before the mould is completely filled. The sand defects which are a source of annoyance in casting then form in these parts. For this reason, quartz sand can be used only to a limited extent in the casting of large pieces of weights of up to about 20 to 30 metric tons.

It was necessary to adopt a different moulding material to enable heavy castings to be manufactured. Chamotte sand has proved very suitable in this connection since steel casting started. Chamotte has a uniform thermal expansion behaviour without any expansion cracks. The expansion defects which are a source of annoyance in the case of quartz sand do not occur with chamotte sand, but the latter has the disadvantage that it cannot be bound — as quartz sand can — with the binders conventional for the latter moulding material, such as bentonite, water glass, linseed oil, synthetic resin, etc. The great advantage of these binders is that the mould requires only slight drying, if any, for the purposes of binder setting. Another advantage of these binders is that they give the mould very good disintegration properties, i.e., the mould disintegrates automatically after the casting has solidified, so that very little blasting is required to remove the residue from the mould.

Chamotte sand, on the other hand, still has to be bound with a refractory binding clay which, although it gives the mould very high mechanical strength makes it necessary for the clay-bound chamotte sand mould to be subjected to very intensive drying. The drying temperature is usually

between 500 and 700°C and depending upon the size of the casting the drying time is between six hours and possibly several days. Consequently, considerable expenditure is incurred in the capital investment and operation of such drying plants. Also, such drying plants or — generally speaking — the drying of the moulds, takes up a considerable amount of space, for example in the case of moulds with a base. If the drying plant could be dispensed with, the output per unit area of a foundry could be greatly increased.

The other moulding materials used in foundries apart from quartz sand and chamotte sand, e.g. chromium ore sand and zirconium sand, are distinguished by very high refractory properties. They are generally bound with the binders known in connection with quartz sand. Like chamotte sands, they are both free from thermal expansion anomalies of the kind encountered with quartz. Owing to their high refractory properties and good thermal conductivity, they are used at those areas of a mould which are subjected to high thermal and corrosive stresses. The disadvantage of these two moulding materials are their high cost and high specific gravity. Only about half the casting moulds can be produced per unit of volume with chromium ore or zirconium sand, compared with quartz or chamotte sand.

On this basis of this prior art, the object of the invention is to provide a moulding material which obviates the disadvantages of the moulding materials used heretofore. This moulding material should be distinguished by the following properties:

1. It must not have any thermal expansion anomalies like quartz, thus obviating sand expansion defects.

2. It must be adapted to be bound with the conventional quartz sand binders if all the advantages of such binders compared with clay binding are to be fully utilised.

3. The new moulding material must have a specific gravity which is lower than that of chromium ore sand or zirconium sand, but which is of the order of chamotte or quartz sand.

4. It should also be possible to produce the new moulding material as a synthetic resin enveloped or coated sand.

To this end, according to the invention, in a new method of producing moulding sands for foundry purposes, non-bloating raw clay is ground, the ground grains are granulated to form substantially spherical granulations of a grain size in the range 0.1 to 1.0 mm, and those granulations are sintered (as hereinafter defined) at a temperature in the range 1200° to 1500°C to yield a moulding sand having a specific area per individual grain below 150 cm^2/g and a water absorbency of below 5%. Unlike the expanded clay process, sintering is carried out without expanding (i.e. non-bloating raw clay is used). The term "sintering" as used in this Specification (including the claims thereof) in relation to the method of the invention means heating so that a fused surface layer or film is formed on the individual grains of the granulate.

A method of producing calcined chamotte as a leaning material for ceramics mouldings is already known, wherein pulverised dried clays are crumbled with a liquid or an aqueous paste, e.g. a clay suspension, and are then subjected to the conventional calcining process for the production of calcined chamotte. A calcining process of this type is not comparable to the sintering operation in the method according to the invention. In addition, the conditions and effects obtaining in the production of ceramics moulding are fundamentally different from those applying to moulding sands for foundry purposes.

The method according to the invention differs fundamentally from the production processes conventional heretofore for the production of chamotte sands for foundry purposes. In the prior art method, clay obtained in underground or open workings is burned in the form of clods, lumps or briquettes in shaft kilns, chamber kilns, tunnel kilns or tubular rotary kilns at temperatures between 1250 and 1400°C. In such conditions, the water of crystallisation content of the clay is eliminated and an unplastic chamotte is obtained with a rock-like character. After cooling, the burned clod(s), lump(s) or briquette(s) is/are pulverised by grinding in impeller drum or ball mills. This pulverisation gives a splintery grain having a shape differing considerably from the spherical. The chamotte grain obtained with this method thus has a much greater specific area. The pulverisation operation is also disadvantageous in the following respect: during the burning operation, each ceramic particle acquires a skin, i.e., a thin surface film, which, as a result of the direct heat action, is sintered more intensively than the layers situated therebeneath. This skin, which opposes any entry of liquids, is destroyed during the grinding operation. Both the enlargement of the specific area and the destruction of the said skin have the effect that the chamotte sands produced by this prior art method cannot be used with binders generally used in foundries for quartz, zirconium or chromite sand, since the consumption of binder is too great and hence too expensive owing to the unfavourable surface and structure of the crushed chamotte grain. The method according to the invention obviates these disadvantages.

In detail, the method according to the invention is performed with the grinding operation, granulation and sintering carried out in such a manner that the specific area of the individual grain of the product is less than 150 cm^2/g. The granulation and sintering operations are so carried out that the water absorbency of the product is less than 5%.

The advantage of the invention is the production of a chamotte sand whose individual grains have a specific geometric shape and specific textural properties. It is an important feature in this connection that both the special geometric shape and the required textural properties should be embodied simultaneously. If just the geometric shape requirement were satisfied and the required textural properties were disregarded, the advantages according to the invention will not be obtained.

The geometric shape of the individual grain must not be splintery. It should be as close as possible to the spherical shape. The approximation to the spherical shape can be expressed as a measurement by the specific area. To achieve the advantages according to the invention, the specific area of the chamotte sand as determined by the George-Fischer sand area gauge, type SPOF (GF 590994), should be less than 150 cm^2/g. If it is below this value, it is possible to use a very economic amount of binder just as with quartz sand.

Apart from the approximation of the geometric shape of the individual grain to the spherical shape, it is important that the textural properties of the individual grain should be as follows:

Each individual grain must have a densely sintered surface and a substantially dense inner texture. The physical value indicative of this—and which must be observed in this connection—is the water absorbency.

To embody the principle of the invention, the water absorbency should be less than 5%.

By observing the above geometric and physical conditions, it is possible to use chamotte sand according to the invention universally with considerable advantages over the mould sands hitherto used in the foundry.

It is also possible to coat the chamotte sand according to the invention with a synthetic resin.

To achieve the above-described physical properties of the new chamotte sand, the following steps must be observed in the process. The starting material for the chamotte sand is a non-bloating raw clay obtained from underground or open workings. It has been found advantageous for the refractory value of this clay to be at least equal to or greater than SK 28 (Seger cone; German standards DIN 51063, December 1954). It is an advantage of the method according to the invention that clays having a lower refractory value can also be used. The first step in the method in that case is not a simple grinding operation but a combined grinding and mixing operation. A high alumina content aggregate is then added to the clay during grinding or, after grinding, in a separate mixer. This high alumina content aggregate may be calcined alumina, bauxite, or high alumina content slag.

The grain size obtained during grinding depends upon the granulating unit used subsequently. The grinder setting also depends upon the final grain sizes required for the chamotte sand. To obtain a finished chamotte sand of a grain size of 0.1 to 0.6 mm, a grain size of the ground clay of less than 0.1 mm is required.

Granulation is the next step in the process after grinding. Any commercial granulating equipment can be used for this purpose provided that they can carry out fine-grain granulation of a grain range from 0.1 to 1.0 mm.

During granulation it is advantageous to add other additives to the clay to assist in forming the spherical shape of the chamotte sand which is necessary for the process. These additives will be distinguished by high interfacial energy against air when in the molten fluid state. Such additives may be MgO having a sigma of 1090 dyn/cm and Al_2O_3 having a sigma of 905 dyn/cm. "Sigma" is a measure of the interfacial energy of a substance against air and is the work necessary to produce an increase in surface in the molten fluid state. It has been found that the amount of these substances added should be about 5% by weight.

Also, at the end of the granulation operation, sintering additives may be added to the granulated clay to facilitate dense sintering of the spherical surface during the sintering operation. Sintering additives of this kind are, for example, borax, calcined soda, and potash feldspar. Since the substances are also strong fluxes, they should not be added in quantities of more than 1% by weight.

In performing the process it has been found very advantageous for the granulating operation to be followed by a screening operation. This screening operation enables specific grain sizes to be obtained immediately after burning, allowing for drying and burning shrinkage. The inclusion of a screen between the granulating and sintering operations has the advantage that the sintering operation is not loaded by unusable deficient or excessive grain sizes. The yield of the kiln in respect of usable grain sizes is thus increased. Screening out the very fine grains also ensures that there is no undesir-

able caking of very fine grains for the required grain sizes during the sintering process, since such caking changes the required spherical shape unacceptably during burning.

The inclusion of the screening plant also reduces dust nuisance in the kiln plant.

The actual sintering operation is carried out in known sintering units. Tubular rotary kilns or fluidised bed kilns have proved very suitable for the method according to the invention. The requirements for the sintering unit are as follows:

The sintering level and time must be of variable adjustment so that the specific area of the individual grain is below 150 cm^2/g and its water absorbency is below 5%, depending upon the mineralogical properties of the clay.

The sintering temperatures required for the method are between 1200 and 1500°. Temperatures of 1300° have proved suitable for known refractory clays.

It is important that the sintering operation should be so carried out as to ensure minimum caking of the individual grains to one another. The end product leaving the kiln must be a chamotte sand having a definitely rounded surface.

From the point of view of thermal consumption it has proved advantageous to follow the sintering operation by a cooling operation in which the chamotte sand is cooled and the heat evolved is recovered and fed to the firing system.

All the binders conventionally used at the present time can be used in metal, ferrous and steel foundries with the chamotte sand produced by these steps, without it being necessary to use a higher proportion of binder than with quartz sand. The binders used in foundries are, on the one hand, organic, e.g. phenolic resin, furan resin, linseed oil, and dextrin. The amount of binder required for binding purposes with organic binders is between 2 and 4%. The amount of hardener, e.g. toluenesulphonic acid or phosphoric acid, required for binding with synthetic resins, is 0.5 to 2%.

Apart from the organic binders, the chamotte sands produced by this method can also be bound with inorganic binders (including silicates). These are, for example, bentonite, refractory clays, water glass ethyl silicate, and aluminium phosphate. Here again, the quantities of binder required are of the same order as for binding quartz sand and are between 2 and 5%. The combination of inorganic and organic binders, e.g. bentonite-starch binders, which is also often used in foundries, can also be used for the chamotte sands produced by the method according to the application.

The mixing operation is carried out with conventional foundry mixers, e.g. edge mill mixers, core sand mixers, or impellers. The chamotte sand provided with the binder is made up into moulds by conventional fonundry methods and machines, e.g. hand ramming, jolt ramming machines, jolt squeeze machines, core shooters, or core blowers.

After being made up, the chamotte sand moulds are subjected to a drying or hardening process depending upon the manufacturers' specifications of the binder used. Dressing of the mould surface as used in the foundry to give smooth casting surfaces, can be carried out with the chamotte sand moulds to the same extent as known with quartz sand moulds. After the dressing operation the chamotte sand mould is ready for casting.

Recently, a mould production process which has become increasingly used in the foundry is one in which the sands are enveloped or coated with synthetic resin. These synthetic resin coated sands are shot into hot moulds or core boxes, where they immediately harden. The chamotte sands prepared by the method according to the invention may be coated with synthetic resin to form such a coated sand. In this case, the last stage of the method is a synthetic resin coating plant in which the chamotte sand prepared by the method described above is coated with synthetic resin. Depending upon the type of coating process, the said plant can be operated as a hot or cold coating plant.

WHAT WE CLAIM IS:—

1. A method of producing chamotte-based moulding sands for foundry purposes, characterised in that non-bloating raw clay is ground, the ground grains are granulated to form substantially spherical granulations of a grain size in the range 0.1 to 1.0 mm., and those granulations are sintered (as hereinbefore defined) at a temperature in the range 1200°C to 1500°C to yield a moulding sand having a water absorbency of below 5% and a specific area per individual grain below 150 cm^2/g.

2. A method as claimed in Claim 1 wherein the refractory value of the raw clay is at least SK 28 (as hereinbefore defined).

3. A method as claimed in Claim 1 wherein the refractory value of the raw clay is less than SK 28 (as hereinbefore defined) and a high alumina content aggregate is admixed with the clay during or after grinding.

4. A method as claimed in Claim 3 wherein the aggregate is calcined alumina, bauxite or high alumina content slag.

5. A method as claimed in any one of the preceding claims characterised in that the granulating operation is followed by a screening operation.

6. A method as claimed in any one of

the preceding claims characterised in that MgO or Al_2O_3 is added during the granulating operation to encourage formation of spherical granulations.

7. A method as claimed in any one of the preceding claims characterised in that sintering agents are added just before the end of the granulating operation.

8. A method of producing chamotte-based moulding sands as claimed in Claim 1 and substantially as herein described.

9. A method as claimed in any one of Claims 1 to 7 characterised in that the sintered product is coated with a synthetic resin.

10. A moulding sand produced by the method claimed in any one of the preceding claims.

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